At UCSC, THE SKY IS NOT THE LIMIT...

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Astronomy professor Connie Rockosi is a bright light in the Sloan Digital Sky Survey, which aims to discover how our galaxy was born.
On Friday nights, while her high school classmates were going to parties, Connie Rockosi enjoyed a different kind of celebration: star parties at her local astronomy club in Cranford, New Jersey. One night, she saw a star disappear as it passed behind the rings of Saturn and then wink at her through a gap in the rings. Even if she couldn’t see the gap directly, the reappearance of the star proved that it was there.

“It was a neat experience,” she says. “It’s the kind of detective work that we have to do as astronomers, because we can’t go out and poke at the things we observe. We have to tell a story based on very limited and indirect observations. This was my first taste of what it’s like to do science.”

Now, as an astronomy professor at UC Santa Cruz, Rockosi, 40, has the opportunity to practice this kind of deduction on a regular basis. She studies the history and structure of our Milky Way galaxy. But you can’t see what the Milky Way looked like 5 or 10 billion years ago through any telescope. You have to piece together the clues and tell a story.

Rockosi has already found enough clues to completely change astronomers’ view of the Milky Way. Instead of a relatively placid whirlpool of gas that condensed and formed a spiral of stars, we now know that the Milky Way has been a voracious feeder on smaller, nearby galaxies. Rockosi and her colleagues have identified several streams of stars that are moving at a different velocity from the surrounding stars. These streams are the torn-apart shreds of a devoured galaxy. Though the stars have been assimilated by the Milky Way, their anomalous motion is a relic of the galaxy that they grew up in.

The discovery would not have been possible without the Sloan Digital Sky Survey (SDSS), a huge collaborative project funded by the Alfred P. Sloan Foundation that has assembled a virtual encyclopedia of stars and galaxies.

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To find a stream of stars moving at the "wrong" velocity, as Rockosi did, you have to look at lots of stars, and you have to survey a vast area, because the Milky Way is all around us. In other words, you need an archive just like the one that SDSS has compiled.

**Birth of a survey**

It’s no accident that the Sloan Digital Sky Survey came along just in time for Rockosi’s research, because she helped build the equipment in the first place. She began working on the project in 1992, when she was still an undergraduate at Princeton University and the telescope existed only on the drawing board of her professor, James Gunn. She has continued to work for the Sloan survey ever since.

Gunn, the project’s chief scientist, envisioned a new kind of telescope with a huge field of view, which could simultaneously measure the spectra of 640 different stars or galaxies, like a fly with 640 eyes.

The “eyes”—or detectors—that would make or break the project, a new generation of devices, weren’t even available yet. When they finally did arrive, they were beyond finicky. Each one was a precision instrument that differed from all the others, and needed an engineer who knew exactly how that particular detector behaved. That engineer turned out to be Connie Rockosi.

“She started in the spring of her junior year,” Gunn says. “I knew that she was considered the star student of the electrical engineering department. She turned out to be every bit as good, if not better, than everyone said.”

Her first project was building circuit boards for the detectors, which she did so well that Gunn asked her to keep working on the Sloan camera while she was in graduate school at the University of Chicago. Although it meant putting her dissertation on hold, she shepherded the camera from the drawing board to its installation at Apache Point, New Mexico, in 1998.

As the rest of the telescope came on line, she took on more and more responsibility for running it. By the time Rockosi joined the UC Santa Cruz Astronomy Department in 2004, “she knew more about the nitty-gritty of that telescope than I did,” says Gunn.

Rockosi received a 2006 Packard Fellowship for Science and Engineering—one of the nation’s most prestigious honors for young faculty members.

**Technical talent**

To her colleagues on the Sloan project, Rockosi’s technical skills became legendary.

“My first time at Apache Point Observatory was in August 1999, just when they were bringing the spectrographs out,” says David Schlegel of Lawrence Berkeley National Laboratory. “Everything was already broken. I kept hearing people say, ‘Connie will be out here soon, she’ll fix it.’ So one day I’m chitchatting at a meal with a person named Connie, who looked about 16 years old.”
About halfway into the conversation I had this epiphany: Connie! You must be the person everyone is talking about! In my mind she was such a towering figure, I had thought she must be much older."

It isn’t just machines that Rockosi has learned to handle. In the current funding cycle, called Sloan-III, she coordinated the Milky Way part of the survey, which meant managing people.

“She understands politics like no one her age I’ve ever met,” says Heather Morrison of Case Western Reserve University. "She doesn’t have an ego that needs to be stroked or coddled. She understands when people might be getting peeved about something, and she is ahead of you in worrying about that. And she is very protective of the needs of graduate students."

The increased focus on the Milky Way is itself a major evolution of the Sloan Digital Sky Survey, which was originally intended to answer large-scale cosmological questions about the structure of the universe.

Sloan-I was essentially a survey of galaxies and quasars, which collected data on the stars in our own galaxy only as a byproduct. They were like bugs on the windshield that the telescope had to look through.

But a funny thing happened: the bugs on the windshield turned out to form interesting patterns. The telescope was seeing mostly stars that are in the Milky Way but lie outside the main disk, in the so-called halo.

"The cartoon picture we all learned in graduate school was that the halo was pretty uniform," Rockosi said.

However, Brian Yanny of Fermilab and Heidi Newberg of Rensselaer Polytechnic Institute found clumps and streams of stars in the halo.

"That fits well with the theory that galaxies form from smaller dwarf galaxies that merge together to form a larger one," Rockosi says. She is now continuing their work with her own students, trying to determine how common these mergers have been, and how many mergers it takes to form a Milky Way.

"Although we’re looking at our own galaxy, we’re doing cosmology too," Rockosi says. "We’re trying to understand whether our galaxy fits the picture of how we think galaxies form. We just get to do it up close and personal, on smaller scales."

### Weighing the galaxy

One of the projects Rockosi has in mind for the future sounds deceptively easy: to weigh the galaxy. In fact, nobody quite knows how much mass there is in the Milky Way. To figure that out, you need to study the orbits of stars that are as far away as possible from the center.

"The problem is that the galaxy is not made up just of stars, but mostly out of dark matter," Rockosi says. "The stars are all concentrated at the center. The most interesting places to look at are far out, and that’s where the fewest stars are. That’s why you need a big survey and a big view of the sky, to pick out these very rare objects."

At present, Sloan-III is funded through the summer of 2014. Beyond that, everybody on the team hopes for continued support from the Sloan Foundation, and the science projects for a prospective fourth round have already been selected.

One other change will also take effect. Gunn, Rockosi’s mentor, is planning to retire from his position as operations coordinator for the survey. Beginning in 2014, Rockosi will take over his duties.

"I can’t imagine Sloan-IV happening without her," Gunn says.

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